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HUNGARIAN EXPERIMENTS IN DEEP FREEZING FISH

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Lake Balaton, Hungary's greatest natural body of water, embraces an area of 106,549 cadstral yokes and has long been exploited by a well-developed fishing industry. Various projects are already in the planning stage to provide an increase of fish through artificial breeding and stocking. However, we are still far from fulfilling the requirements. The present fish catch in Lake Balaton amounts to about 120 carloads per year and averages about 40 carloads of "good fish" (pike, perch, sheatfish, carp, etc.). The "white fish," consisting for the most part of palatable whiting and shad, amount to about 80 carloads. The majority of fish found in Lake Blaton are whitings.

Although much attention has been devoted to the exploitation of the famous Balaton pike perch (fogas sullo), the large quantities of the white fish have not been utilized properly. The boniness of this fish has somewhat reduced the demand for it, however, its meat which could be rendered palatable for public consumption through industrial processing, and use could be made of the waste products, such as scales, heads, etc., obtained in the course of processing the fish. In the past, the Lake Balaton Fisheries Enterprise attempted to utilize the mass of white fish caught in Lake Balaton for the production of fish meal in the plant at Fonyod. The fish have also been sold at nominal prices to farmers engaged in fattening hogs. Neither the inefficient method of producing fish meal, nor the irrational marketing of white fish as hog fodder at lower than cost prices can be considered as benefiting the Balaton fisheries. The attempts to erect scaling plants according to a foreign pattern and the establishment of a fish-paste manufacturing plant at Siofok did not produce the expected results.

The lack of proteins, felt all over Europe, has focused attention on the considerable protein resources of Lake Balaton. The large amounts of fish found in Lake Balaton are in great demand not only for immediate consumption but also for

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the canning industry which uses them for excellent fish conserves and marinades. However, the fairly unpredictable results of Lake Balaton fish catches limit the possibility of meeting increased demands. Unexpectedly large catches of fish are followed by smaller catches. This situation, together with the tendency of fish to deteriorate quickly makes a planned fish supply for canneries and the retail market subject to almost insurmountable difficulties.

The methods of refrigeration employed to date, such as using ice. have kept the Balaton fish from deterioration for a very short time only. Keeping fish on ice for many days may produce a damaging effect on the quality; the processes of putrefaction may start, and the water of the melting ice, filled with injurious bacteria, may seep through the entire lot of fish and contaminate it. Moreover, the operations connected with freezing fish by using ice, together with the time required for such operations, cannot be considered economical when dealing with large quantities.

The foregoing considerations and the prospects for increasingly greater yields from the Lake Balaton fishery, with its increased importance for the fish processing industry, have induced the Balaton Fisheries Enterprise to concentrate on the problem of preserving freshly caught fish by deep freezing. In the fall of 1950, experiments were begun in the experimental deep freezer of the Deep Freezing Division of the National Agricultural Industrial Research Institute. Istvan Varga, mechanical engineer, took charge of the research for the planning and execution of these experiments, while Bela Szelestey, supervisor of the Lake Balaton Fisheries Enterprise, assisted the writer of this article in technological details.

The fish-freezing methods used abroad cannot very well be used in the Hungarian economy because of the disadvantages connected with them; they were designed to handle large amounts of marine fish and continuous operation is necessary.

Our experiments have been carried out in separately built experimental blast-freezing chambers in the Agricultural Industrial Research Institute, where a temperature as low as minus 42 degrees centigrade, accompanied by powerful air ventilation, has been obtained. Considering the quality of the frozen substances, the results were excellent. Guided by economic considerations, as well as operative requirements, we came to the conclusion that the blast-freezing equipment using the tunnel system developed by Soviet Engineer S. L. Gimpelevich was most suitable for the domestic fish industry.

This equipment has been designed for the quick-freezing of medium-sized fish (carp, perch, whiting), but it can also be used for the quick-freezing of other food, such as poultry. It is well suited for domestic requirements. The over-all size of the equipment is 4.2 x 4.1 x 1.63 meters. Small tracks pass through the apparatus on which four carts can be placed. The fish to be frozen are placed in these carts. The frozen material is discharged at the other end of the apparatus, thus providing for continuous operations. The blowers, driven by two electric moters can produce an air current of 6 meters per second. Two heating elements, each of 10 kilowatts, are used for removing the ice deposited on the cooling tubes. According to experiments made in the Soviet Union, medium-sized fish were frozen from plus 5 degrees centigrade to minus 10 degrees centigrade within 3 hours in Gempelevich's apparatus at a temperature of minus 20 degrees centigrade, with an air current of 3 meters per second. The quality of the frozen fish was good and the freezing uniform. The degree of efficiency described in the foregoing may be increased by properly adjusting the measurements of the equipment and by regulating the output of the compressor.

There is a different method used abroad, expecially in connection with eels (Friedrich, Douglas, and Donald). Experiment has shown us that in other respects this method was most economical in the deep freezing and storage of large amounts of fish caught in Lake Balaton, such as whiting and shad.

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Experiments in which the requirements of the domestic market have been taken into consideration showed the following results:

I. DEEP FREEZING BY AIR

The following fish were received on 27 September 1950 from the Siofok plant of the Lake Balaton Fisheries Enterprise, delivered by ice-equipped truck: (a) 20 whitings, gross weight, 3.80 kilograms, in a wooden box with perforated metal bottom; and (b) 10 whitings, gross weight 3.00 kilograms, 2 carps, second grade, gross weight, 2.80 kilograms; one sable fish, gross weight 0.17 kilograms; and one shad, gross weight 0.26 kilogram in a basket.

All of the fish were freshly caught.

Preparation of Fish

The fish were placed in wire baskets, sprayed with water and cleaned. One of the carp was gutted, the other was placed whole in the quick-freeze equipment after a thermometer had been inserted into the body. The gutted carp was a spawner which, after the roe had been removed, was placed in a paraffined box and frozen separately.

One of the two perches was frozen without gutting, while four filets were prepared from the other; these were placed in a paraffined in the quick-freeze equipment.

The whitings in the perforated box were frozen together, while those in the basket were frozen individually. In each case a thermometer was stuck into one of the whitings. The fish thus prepared were then placed separately on the shelves of the carts, with the exception of the whitings received in the perforated box, which were frozen together, one upon the other, in the box itself.

Blast Freezing

The freezing was done in the experimental deep freeze chamber of the National Agricultural Industrial Research Institute. The refrigerant used was ammonia. A powerful blower circulated the air in the chamber.

Process of Blast Freezing

Stage	Time	Temperature (degrees centigrade) In the Freezing Chamber	In the Body of a Carp (1.5 kg)	In the Body of a Whiting (0.2 kg)
Begun at	1135	- 10	+ 5	+ 7
After 1 hr 25 min	1300	- 26	0	- 3
After 2 hr 45 min	1420	- 37	- 5.4	- 30
Concluded at	1535	- 42	- 30	- 42

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After Freezing

The fish were frozen hard and the thin whitings were especially brittle. White frost had settled on the surface of the fish; their exterior appeared very attractive and appetizing.

Glazing

The fish were immersed in a tank of water for 10 to 20 seconds and their surfaces were completely covered by an ice layer within a few seconds.

Evaluation of Experimental Blast Freezing

The results were good, but too much time was consumed in the freezing process; as a result, the degree of efficiency was not satisfactory, especially for large amounts of fish. A somewhat higher temperature (minus 25 to minus 35 degrees centigrade) will suffice instead of the temperature of minus 42 degrees centigrade obtained in the final stage as shown above for continuous operation. Still better results are expected from the installation of blast-freezing equipment using the tunnel system (such as the Gimpelevich design).

Microscopic histological tests carried out after deep freezing have yielded the expected good results. The cells and muscle fibers with transverse streaks were found uninjured, in the thin whitings as well as in the more substantial bodies of the carps. Only occasionally could minor wrinkles be seen, but no laceration or deterioration could be observed.

Freezing Storage

The glazed fish were placed on shelves separately, and the unglazed filets and roe were placed in paraffined boxes, and kept at minus 20 degrees centigrade without ventilation.

Storage began: 27 September 1950
Storage concluded: 16 January 1951
Duration of storage: 122 days

Record of Weight Loss

		Weight After Quick-Freezing (dekagrams)			
Unit of Fish	Type	Glazed	Unglazed	After 4 months' Storage at $-20^{\circ}C$	Loss in Weight
1 piece	Whiting	22.5	--	20.0	2.5
1 piece	Perch	19.0	--	17.0	2.0
1 paraffined box	Sable (4 filets)	--	63.5	62.0	1.5
1 paraffined box	Carp roe	--	20.5	20.0	0.5

It will be seen from the foregoing that the loss of weight sustained in storage is minimal; in the case of glazed fish, it is restricted to diminution of the ice layer.

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External inspection of the fish after freezing and storage showed that the fish had the same, attractive, appetizing appearance; the scales and fins were perfect; there was no change in the color, nor any deformation. The whitings wrapped in the box were frozen together and the bodies bent.

Thawing Tests

1. At Room Temperature

On 16 January 1951, at 1145 hours, the fish were removed from the freezing chamber and placed in a warm room. By 0815 hours, on 17 January the uniform, slow thawing of the larger fish (carp, sable) was completed. Room temperature during the thawing process: minimum 15.5 degrees centigrade; maximum 20.0 degrees centigrade; the average temperature was 17.5 degrees centigrade. The body temperature of carps when placed in the room was minus 20 degrees centigrade; at the conclusion of the thawing process the temperature was 14 degrees centigrade. The temperature in the whitings went from minus 23 degrees centigrade to 16 degrees centigrade. The fish lost rigidity in a uniform manner during the thawing process; there was no subsequent change in color, their smell was fresh, the gills were red, the epidermis perfect. The thawed fish gave the impression of appetizing, fresh fish, the same was true of the unglazed filets frozen in paraffined boxes. On the other hand, the delicate, moist carp roe was ruined during the freezing process.

2. Thawing in Water

Whitings thawed in water showed the following results:

a. In continuously running tap water at 10 degrees centigrade; begun at 1220, terminated at 1235. Thawing period: 15 minutes.

b. In standing water 10 degrees centigrade; begun at 1222, terminated at 1255. Thawing period: 33 minutes.

c. In standing water at 25 degrees centigrade; begun at 1232, terminated at 1300. Thawing period: 28 minutes.

The quality of the fish after thawing was as follows: In the case of (b) and (c) the exterior of the fish is less attractive than in (a). Especially in the case of (c), heavy slime and subsequent discoloration were noticed. The whitings assumed an intense red color; the fish were swollen. The best results were obtained by using running tap water. Uniform thawing in open air produced fish of good quality, but running tap water assures the shortest thawing period.

Taste Test

The flavor of every deep frozen fish was uniformly satisfactory, regardless of whether or not it had been gutted, provided the thawing process took place uniformly at room temperature or in running tap water. The same was true of filets frozen in paraffined boxes. The meat of the fish did not fall apart; it was not flaccid. It was solid to the extent desired, compact and tasty. Several experts agreed that the taste of the deep frozen experimental fish was similar to that of the special, freshly caught fish of Lake Balaton.

II. FREEZING INTO ICE BLOCKS

The following operational disadvantages were observed in the air freezing of whiting, shad, red-finned rudd, silver fish, etc., caught in Lake Balaton: (1) these fish required much space when spread out individually on the sliding shelves of the freezing equipment; (2) whitings, frozen together in boxes or in mass, did not meet consumer requirements; (3) air-frozen fish required special treatment in storing and glazing; and (4) transportation and retail handling presented great difficulties in connection with thin-bodied fish, as they became very brittle when frozen.

Since the costs involved in deep freezing were prohibitive from an economic viewpoint, we endeavored to work out a deep freezing process, with the above-mentioned disadvantages eliminated, that would permit deep freezing of large quantities in an economical manner.

On 24 January 1951, 50 kilograms of freshly caught whiting, iced in baskets, were delivered by trucks to Siofok. Among the whitings were a few shad, silver fish, and red-finned rudd.

Preparation

The fish were placed in large tanks, sprayed with jets of water while being turned from one side to the other, and washed. This operation can be performed mechanically by suitable machinery. Then the experimental ice tray was immediately filled with fish. The experimental ice tray consisted of an ordinary iron-plate form used in the manufacture of artificial ice. It was 110 centimeters high, the upper end was 19 x 12 centimeters, slightly tapering downward. When empty, it weighed 8.5 kilograms. Sixty whitings, closely packed, having a total weight of 10.5 kilograms were placed inside. The space between the fish was filled by pouring in 6.5 kilograms of water, with the result that the ice cell had a total weight of 25.5 kilograms.

Quick Freezing

The ice tray filled with fish and water was suspended in a tank in which a solution of 30 percent calcium chloride circulated, and was quickly frozen by means of a cooling coil using an ammonia refrigerant. Freezing started at 1155 hours, with an initial temperature of minus 31 degrees centigrade. Freezing was completed at 1235 hours, at which time the temperature within the ice block was minus 35 degrees centigrade. Thus, the freezing process required 40 minutes, in contrast to 4 hours for air-freezing.

Storage

The ice tray was removed from the freezing liquid and placed in lukewarm water long enough to melt the surface of the ice block so that it separated from the wall of the form. The ice block of fish was then stored in a chamber at minus 20 degrees centigrade. The block was easily handled and there was no need for special glazing.

Thawing

On 9 February 1951, the block of frozen fish was thawed in a metal trough equipped with a drain pipe. Begun at 1000 hours, the outer layers of fish became disengaged at 1230; the inner layers separated at 1300. Under running tap water the thawing process required about one half this time. Due to the shape of the narrow experimental ice tray, the lower layer of fish, packef from above, became deformed in freezing. Nevertheless, they recovered their original form after thawing. The epidermis was perfect, no discoloration could be observed.

Taste Test

The fish frozen in ice blocks had an excellent flavor; their meat was elastic, firm, and satisfactory in every respect.

Technical Observations

The difficulties encountered in filling the experimental ice tray showed that it was not suitable for commercial use. From a practical view point, a freezing form about 110 centimeters long, 25 to 30 centimeters high, and 35 to 40 centimeters wide, appears to be most suitable. One of its longitudinal sides should open in a manner similar to a box lid; thus, the fish could be placed inside in attractive rows, one next to the other, and one row above the other. A special buffer-frame should be used to prevent the fish from freezing to the walls of the metal form.

Advantages of Ice-Block Freezing

1. By using this process, freezing can be carried out in the shortest period of time, at the least possible expense.

2. Storage expenses will be reduced by eliminating the process of reglazing and systematic controls, and better use of the existing storage facilities will be possible by storing the ice in columns.

3. The fish do not rub together and are not broken in transit.

4. Retailers can obtain the fish in specified weight in the form of ice blocks. From the blocks the required amounts can be thawed from time to time.

In spite of all these advantages, ice-block freezing should be employed only for fish having a relatively small body, while in the case of larger, more valuable fish (sable fish, sheatfish, carp, etc.), as well as filets cut from large fish, the deep-freezing process using the tunnel method of air-freezing is more suitable.

III. SOME PROBLEMS OF PLANT PLANNING

In our country the installation of a special deep freezing establishment for fish would be worthwhile only at Lake Balaton and under government operation, for the fish yield of other natural bodies of water and fisheries, of which only relatively small amounts can be considered as suitable for deep freezing, can very well be processed by the increasing number of decentralized municipal deep freezing establishments. In the interests of processing fresh fish caught in Lake Balaton, it is desirable that a plant be established at Siofok, a centrally located for fishing vessels.

Planning of an economical, continuously operated freezing plant using the tunnel system /see appended figure/ would be the most suitable. In the case of large amounts of small fish, tanks utilizing an ammonia refrigerant and calcium chloride baths should be adequate. This latter equipment could also be used for producing artificial ice, which commodity would play an important part in the food supply of the southern Balaton district.

Storage facilities should be planned with consideration for the fact that the present fish catch, averaging about 20 carloads per month (during the main season of 6 months), is increasing from year to year. Taking into consideration the possibilities of additional development, as well as daily marketing conditions, a

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deep freezer capable of handling 60 carloads should be built. By marketing headless and tailless fish, 30 to 40 percent more could be stored by the frozen storage facilities. To make better use of the freezing equipment and storage facilities, the operations could be extended to include the deep freezing of poultry, fruits, etc., whereby the steadily increasing food production of the southern Balaton district would be expanded. There is no need to fear that these food articles will absorb unpleasant odors, as is erroneously believed by many people.

Evaporation considered injurious stops at the low temperature of minus 20 degrees centigrades which prevails in deep freezing installations. The protection of fish can be increased to a still greater degree by means of glazing, which forms a sealed ice layer around the fish body.

Considering the possibilities of an increase in the domestic fish production and the utilization of fish yields, the introduction of deep freezing promises to become a significant step in the development of our fish economy.

/Appended figure follows./

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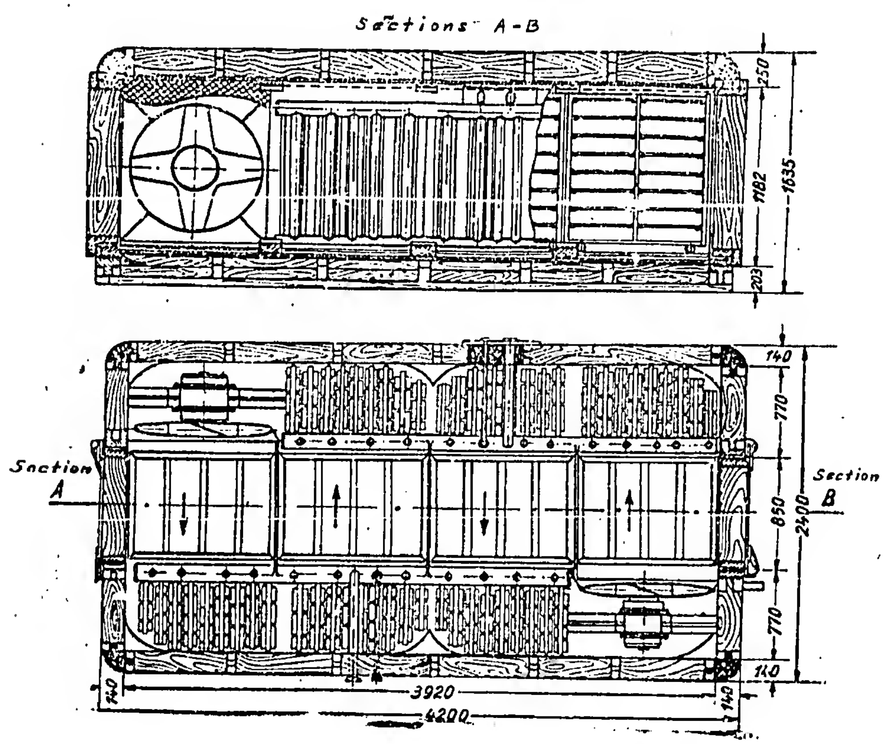

Diagram of Quick-Freezing Equipment Using the Tunnel System
Designed by Soviet Engineer Gimpelevich

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